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Standard

OPEN SYSTEMS ARCHITECTURE AND PROTOCOLS

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DOCUMENT CHANGE NOTICE

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This notice informs recipients that the standard identified by the number (and revision letter) shown in block 4 has been changed. The pages changed by this DCN (being those furnished herewithin) carry the same date as the DCN. The page numbers and dates listed below in the summary of changed pages, combined with nonlisted pages of the original issue of the revision shown in block 4, constitute the current version of this specification.

13. DCN No.	14. Pages changed	S*	A/D*	15. Date
1	This change incorporates the following NCP: 16092. This NCP supercedes FAA-STD-039 in its entirety	S		10/27/93

*S = Indicates Supercedes Earlier Pages *A = Indicates Added Page * D = Indicates Deleted Page

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FOREWORD

This standard establishes a data communications architecture and defines the protocol standards for open systems communications within the National Airspace System (NAS). The architecture defined in this standard is based on the seven layer, Open Systems Interconnection (OSI) Basic Reference Model, as described in the International Organization for Standardization (ISO) document 7498-1.

The NAS will consist of various types of processors and communications networks procured from a variety of vendors. A well defined data communications architecture is required to ensure interoperability between NAS open end-systems.

This standard includes definitions in section 6.1.

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FIGURES

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1. SCOPE

1.1 Scope. This standard specifies a minimal set of protocol and service requirements for the National Airspace System (NAS). The minimum set defined herein may exceed the minimal requirements for a particular end-system, but is necessary to facilitate interoperability. Additional protocols and services may be implemented for interfacing NAS open end-systems by mutual agreement. Requirements for NAS open end-system connectivity to the Aeronautical Telecommunication Network (ATN) are contained in the International Civil Aviation Organization (ICAO) ATN Manual.

The communications architecture and protocols described herein shall be used by Federal Aviation Administration (FAA) in the development of interface requirements as part of the design, procurement, and overall data communications planning of the NAS.

1.2 Purpose. The purpose of this standard is to establish a communications architecture for the modernization of NAS data communication systems. This standard also facilitates a migration for the implementation of OSI standards [ISO, International Telegraph and Telephone Consultative Committee (CCITT), American National Standards Institute (ANSI)] for existing NAS end-systems. It also facilitates interoperability of these systems. The communications architecture defined in this standard will incorporate FAA-developed standards, which are OSI compliant, where international/national standards are not available or feasible in meeting NAS-specific data communications requirements.

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2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents form a part of this standard to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this standard, the contents of this standard shall be considered the superseding requirement.

FAA Standards

FAA-STD-042	National Airspace System (NAS) Open Systems Interconnection (OSI) Naming and Addressing, January 9, 1992
FAA-STD-043	National Airspace System (NAS) Open Systems Interconnection (OSI) Priority, January 9, 1992
FAA-STD-044	National Airspace System (NAS) Open Systems Interconnection (OSI) Directory Services, October 23, 1992

Federal Standards

FED-STD-1020A	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
FED-STD-1030A	Electrical Characteristics of Unbalanced Voltage Digital Iterface Circuits
FED-STD-1032	High Speed 25-position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment
FIPS PUB 107	Baseband Carrier Sense Multiple Access with Collision Detection Access Method and Physical Layer Specifications and Link Layer Protocol
FIPS PUB 146-1	Government Open Systems Interconnection Profile (GOSIP), Version 2.0
FIPS PUB 154	High Speed 25-position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment

National Institute of Standards and Technology

NIST SP-500-206	Stable Implementation Agreements for OSI Protocols, Version 4

2.2 Non-Government Documents

Electronic Industries Association (EIA)

EIA-232D/E	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

EIA-530	High Speed 25-position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment
RS-232C	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
RS-422A	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
RS-423A	Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits

International Civil Aviation Organization

ICAO ATN Manual	Manual of the Aeronautical Telecommunication Network, Second Edition, June 18, 1993

International Telegraph and Telephone Consultative Committee (CCITT)

CCITT V.24	List of Definitions for Interchange Circuits Between Data Terminal Equipment and Data Circuit-Terminating Equipment
CCITT V.28	Electrical Characteristics for Unbalanced Double-Current Interchange Circuits
CCITT V.32A	Family of 2-wire, Duplex Modems Operating at Data Signalling Rates of Up to 9600 Bit/s for Use on the General Switched Telephone Network and on Leased Telephone-Type Circuits
CCITT V.35	Data Transmission at 48 Kilobits Per Second Using 60-108 kHz Group Band Circuits
CCITT X.21 bis	Use on Public Data Networks of Data Terminal Equipment (DTE) Which is Designed for Interfacing to Synchronous V-Series Modems - 1984
CCITT X.25	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks - 1984
CCITT X.29	Procedures for the Exchange of Control Information and User Data Between a Packet Assembly/Disassembly (PAD) Facility and a Packet Mode DTE or Another PAD - 1984

CCITT X.32	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet-Mode and Accessing a Packet Switched Public Data Network through a Public Switched Telephone Network or a Circuit Switched Public Data Network - 1984
CCITT X.121	International Numbering Plan for Public Data Networks

International Organization for Standardization (ISO)

ISO 2110:1989	Information Technology - Data Communication - 25-Pin Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) Interface Connector and Contact Number Assignments, 3rd Edition
ISO 2593:1984	Data Communication - 34-Pin Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) Interface Connector and Pin Assignments, 2nd Edition
ISO 3309:1984	Information Processing Systems - Data Communication - High-level Data Link Control Procedures - Frame Structure, 3rd Edition
ISO 4335:1987	Information Processing Systems - Data Communication - High-Level Data Link Control (HDLC) Elements of Procedures, 3rd Edition
ISO 7478:1987	Information Processing Systems - Data Communication - Multilink Procedures, 1st Edition
ISO 7498-1:1984	Information Processing Systems - Open Systems Interconnection - Part 1: Basic Reference Model, 1st Edition
ISO/IEC 7498-2:1989	Information Processing Systems - Open Systems Interconnection - Basic Reference Model - Part 2: Security Architecture, 1st Edition
ISO/IEC 7498-3:1989	Information Processing Systems - Open Systems Interconnection - Basic Reference Model - Part 3: Naming and Addressing, 1st Edition
ISO/IEC 7498-4:1989	Information Processing Systems - Open Systems Interconnection - Basic Reference Model - Part 4: Management Framework, 1st Edition
ISO 7776:1986	Information Processing Systems - Data Communication - High-Level Data Link Control Procedures - Description of the X.25 LAPB-Compatible DTE Data Link Procedures, Version 1

ISO 7809:1984	Information Processing Systems – Data Communication – High-Level Data Link Control Procedures – Consolidation of Classes of Procedures, 1st Edition
ISO 8072:1986	Information Processing Systems – Open System Interconnection – Transport Service Definition, 1st Edition
ISO/IEC 8073:1988	Information Processing Systems – Open Systems Interconnection – Connection Oriented Transport Protocol Specification, 2nd Edition
ISO/IEC 8073:1988/ AD2:1989	Information Processing Systems – Open Systems Interconnection – Connection Oriented Transport Protocol Specification – Addendum 2: Class four Operation Over Connectionless Network Service
ISO/IEC 8208:1990	Information Processing Systems – Data Communications – X.25 Packet Level Protocol for Data Terminal Equipment, 2nd Edition
ISO 8326:1987	Information Processing Systems – Open Systems Interconnection – Basic Connection Oriented Session Service Definition, 1st Edition
ISO 8326/DAD2	Information Processing Systems – Open Systems Interconnection – Basic Connection Oriented Session Service Definition – Addendum 2: Incorporation of Unlimited User Data, June 1988
ISO 8327:1987	Information Processing Systems – Open Systems Interconnection – Basic Connection Oriented Session Protocol Specification, 1st Edition
ISO 8327/DAD2	Information Processing Systems – Open Systems Interconnection – Basic Connection Oriented Session Protocol Specification – Addendum 2: Incorporation of Unlimited User Data, June 1988
ISO 8348:1987	Information Processing Systems – Data Communications – Network Service Definition, 1st Edition

ISO 8348:1987/ AD1:1987	Information Processing Systems – Data Communications – Network Service Definition – Addendum 1: Connectionless Mode Transmission
ISO 8348:1987/ AD2:1988	Information Processing Systems – Data Communications – Network Service Definition – Addendum 2: Network Layer Addressing
ISO 8473:1988	Information Processing Systems – Data Communications – Protocol for Providing the Connectionless-Mode Network Service (CLNS), 1st Edition
ISO 8473:1988/ AD3:1989	Information Processing Systems – Data Communications – Protocol for Providing the Connectionless-Mode Network Service – Addendum 3: Provision of the Underlying Service Assumed by ISO 8473 over Subnetworks which Provide the OSI Data Link Service, 1st Edition
ISO 8571-1:1988	Information Processing Systems – Open Systems Interconnection – File Transfer, Access, and Management – Part 1: General Introduction, 1st Edition
ISO 8571-2:1988	Information Processing Systems – Open Systems Interconnection – File Transfer, Access, and Management – Part 2: Virtual Filestore Definition, 1st Edition
ISO 8571-3:1988	Information Processing Systems – Open Systems Interconnection – File Transfer, Access, and Management – Part 3: File Service Definition, 1st Edition
ISO 8571-4:1988	Information Processing Systems – Open Systems Interconnection – File Transfer, Access, and Management – Part 4: File Protocol Specification, 1st Edition
ISO 8602:1987	Information Processing Systems – Open Systems Interconnection – Protocol for Providing the Connectionless-mode Transport Service, 1st Edition
ISO 8648:1988	Information Processing Systems – Open Systems Interconnection – Internal Organization of the Network Layer, 1st Edition
ISO 8649:1988	Information Processing Systems – Open Systems Interconnection – Service Definition for the Association Control Service Element, 1st Edition

ISO 8650:1988	Information Processing Systems – Open Systems Interconnection – Protocol Specification for the Association Control Service Element, 1st Edition
ISO/IEC 8802-2:1990	Information Processing Systems – Local Area Networks – Part 2: Logical Link Control, 1st Edition
ISO/IEC 8802-3:1990	Information Processing Systems – Local Area Networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, 2nd Edition
ISO/IEC 8802-4:1990	Information Processing Systems – Local Area Networks – Part 4: Token-Passing Bus Access Method and Physical Layer Specifications, 1st Edition
ISO/IEC 8802-5:1990	Information Processing Systems -Local Area Networks – Part 5: Token Ring Access Method and Physical Layer Specification, 1st Edition
ISO 8822:1988	Information Processing Systems – Open Systems Interconnection – Connection Oriented Presentation Service Definition, 1st Edition
ISO 8823:1988	Information Processing Systems – Open Systems Interconnection – Connection Oriented Presentation Protocol Specification, 1st Edition
ISO 8824:1987	Information Processing Systems – Open Systems Interconnection – Specification of Abstract Syntax Notation One (ASN.1), 1st Edition
ISO 8825:1987	Information Processing Systems – Open Systems Interconnection – Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1), 1st Edition
ISO 8878:1987	Information Processing Systems – Data Communications – Use of X.25 to Provide the OSI Connection-mode Network Service (CONS), 1st Edition
ISO 8880-1:1988	Information Processing Systems – Protocol Combinations to Provide and Support the OSI Network Service – Part 1: General Principles, 1st Edition
ISO 8880-2:1988	Information Processing Systems – Protocol Combinations to Provide and Support the OSI Network Service – Part 2: Provision and Support of the Connection-Mode Network Service, 1st Edition

ISO 8880-3:1988	Information Processing Systems – Protocol Combinations to Provide and Support the OSI Network Service – Part 3: Provision and Support of the Connectionless-Mode Network Service, 1st Edition
ISO/IEC 8886	Information Processing Systems – Data Communication – Data Link Service Definition for Open Systems Interconnection, April 1992
ISO 9040:1990	Information Processing Systems – Open Systems Interconnection – Virtual Terminal Basic Class Service, 1st Edition
ISO 9041-1:1990	Information Processing Systems – Open Systems Interconnection – Virtual Terminal Basic Class Protocol – Part 1: Specification
ISO 9072-1:1989	Information Processing Systems – Text Communication – Remote Operations – Part 1: Model, Notation and Service Definition, 1st Edition
ISO 9072-2:1989	Information Processing Systems – Text Communication – Remote Operations – Part 2: Protocol Specification, 1st Edition
ISO 9314-1:1989	Information Processing Systems – Fibre Distributed Data Interface (FDDI) – Part 1: Physical Layer Protocol (PHY), 1st Edition
ISO 9542:1988	Information Processing Systems – Telecommunications and Information Exchange Between Systems – End System to Intermediate System Routing Exchange Protocol for Use in Conjunction with the Protocol for Providing the Connectionless-mode Network Service
ISO 9545:1988	Information Technology – Open System Interconnection –Application Layer Structure, 1st Edition
ISO/IEC 10021-1:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 1: System and Service Overview
ISO/IEC 10021-2:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 2: Overall Architecture

ISO/IEC 10021-3:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 3: Abstract Service Definition Conventions
ISO/IEC 10021-4:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 4: Message Transfer System: Abstract Service Definition and Procedures
ISO/IEC 10021-5:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 5: Message Store: Abstract Service Definition
ISO/IEC 10021-6:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 6: Protocol Specifications
ISO/IEC 10021-7:1990	Information Processing – Text Communication – Message Oriented Text Interchange System – Part 7: Interpersonal Messaging System
ISO/IEC 10026-1:1992	Information Processing Systems – Open Systems interconnection – Distributed Transaction Processing – Part 1: Model
ISO/IEC 10026-2:1992	Information Processing Systems – Open Systems interconnection – Distributed Transaction Processing – Part 2: Service Definition
ISO/IEC 10026-3:1992	Information Processing Systems – Open Systems interconnection – Distributed Transaction Processing – Part 3: Protocol Specification
ISO/IEC 10589:1992	Information Technology – Telecommunication and Information Exchange between Systems – Intermediate System (IS) to IS – Intra-Domain Routing Information Exchange Protocol for use in conjunction with the Connectionless-mode Network Service.
ISO/IEC 10747:1993	Information Processing Systems – Telecommunications and Information Exchange between Systems – Protocol Exchange of Inter-Domain Routing Information among Intermediate Systems to Support Forwarding of ISO 8473 PDUs

3. REQUIREMENTS

3.1 General. This standard evolved from a requirement to provide a standard data communications architecture and protocols to facilitate the interconnection and interoperability of NAS open end-systems. NAS-SS-1000, Volume IV, paragraph 3.1.4.1, states that all interfaces shall conform to the ISO Basic Reference Model (ISO 7498-1). In addition, this standard supports convergence of FAA interfaces with OSI interface profiles to the extent compatible with specific FAA Mission elements, including the FAA primary mission to provide for "...safe and efficient air traffic control...".

The implementation of an OSI architecture is specified as a general requirement, together with the use of appropriate ISO/CCITT/Institute of Electrical and Electronics Engineers (IEEE) and FAA-unique protocols for providing a set of standardized services. The protocol implementation requirements defined in this document are based on the Government Open Systems Interconnection Profile (GOSIP), FIPS PUB 146-1, and the Stable Implementation Agreements for OSI Protocols, NIST SP-500-206.

3.2 NAS Open System Profile. The NAS open systems data communications architecture shall be compliant with the OSI Basic Reference Model shown in Figure 1. The reference model can be divided into two groups of layers; upper layers and lower layers.

The first four OSI layers form the "lower layers" of the ISO/OSI model. These provide the end-to-end services responsible for data transfer. The remaining three OSI layers form the "upper layers" of the ISO/OSI model. These provide the application services responsible for information transfer. The NAS open end-systems profile defines the services and protocols selected for use at each layer.

The reference model can be divided into two groups of layers; upper layers and lower layers. Figures 2, 3, and 4 show the protocol architecture to be used for NAS open end-system communicating via the wide area networks (i.e., the NADIN PSN), Advanced Automation System (AAS) Local Communications Network (LCN), and Local Area Networks (LAN). Figures 5, 6, 7, 8, and 9 show the protocol architecture for NAS routers to be used when enabling communications between open end systems on separate subnetworks. The technical characteristics of each protocol standard and service definition are defined herein. Requirements for NAS open end-system connectivity to the Aeronautical Telecommunication Network (ATN) are contained in the International Civil Aviation Organization (ICAO) ATN Manual.

3.2.1 Upper-Layers. Layers 5, 6, and 7 (Session, Presentation, and Application) of the OSI Reference Model are responsible for the protocols necessary to allow two dissimilar systems to understand each other and communicate. This section describes the protocols selected for the implementation of the OSI upper-layers in the NAS.

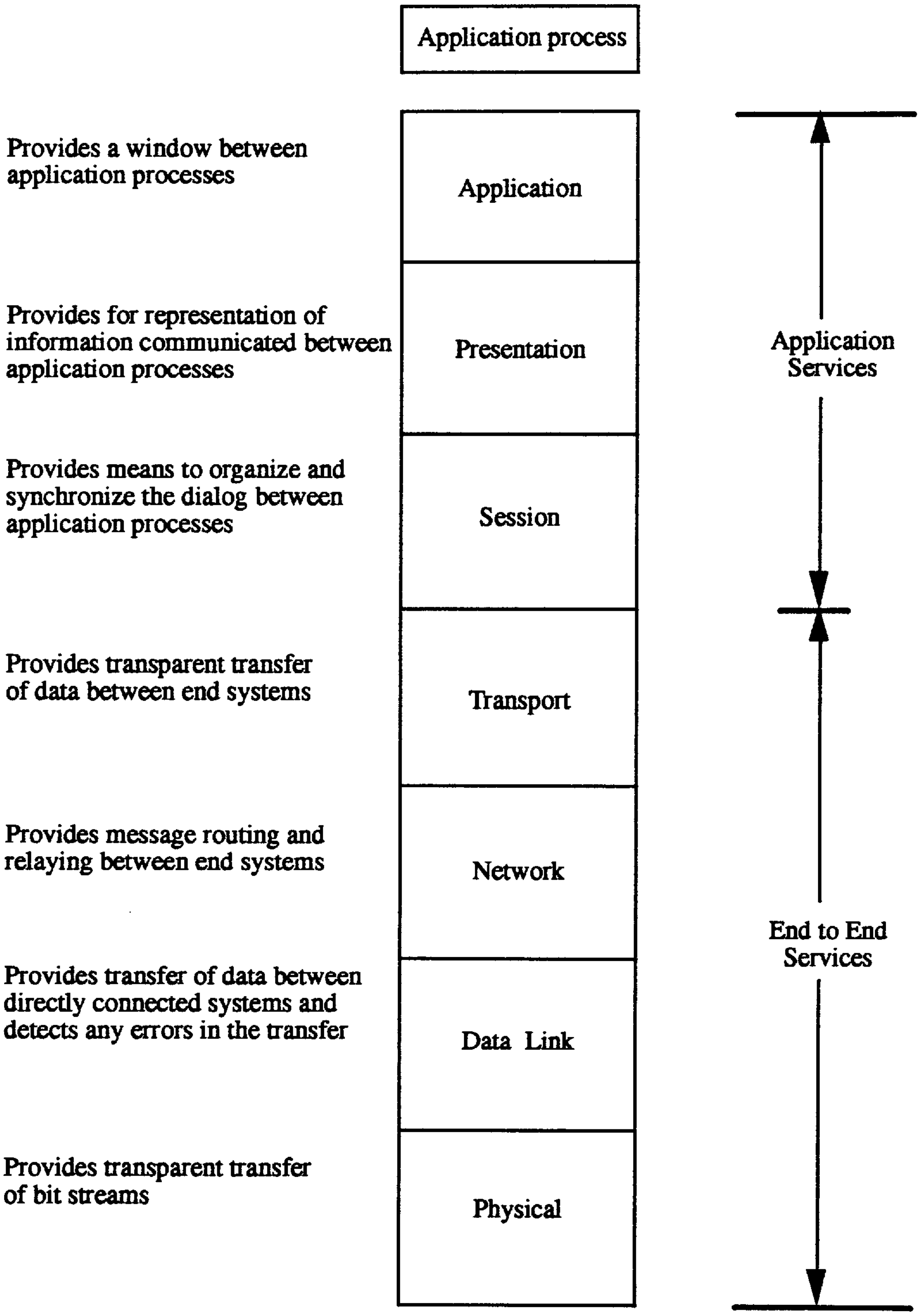

FIGURE 1 OSI Basic Reference Model

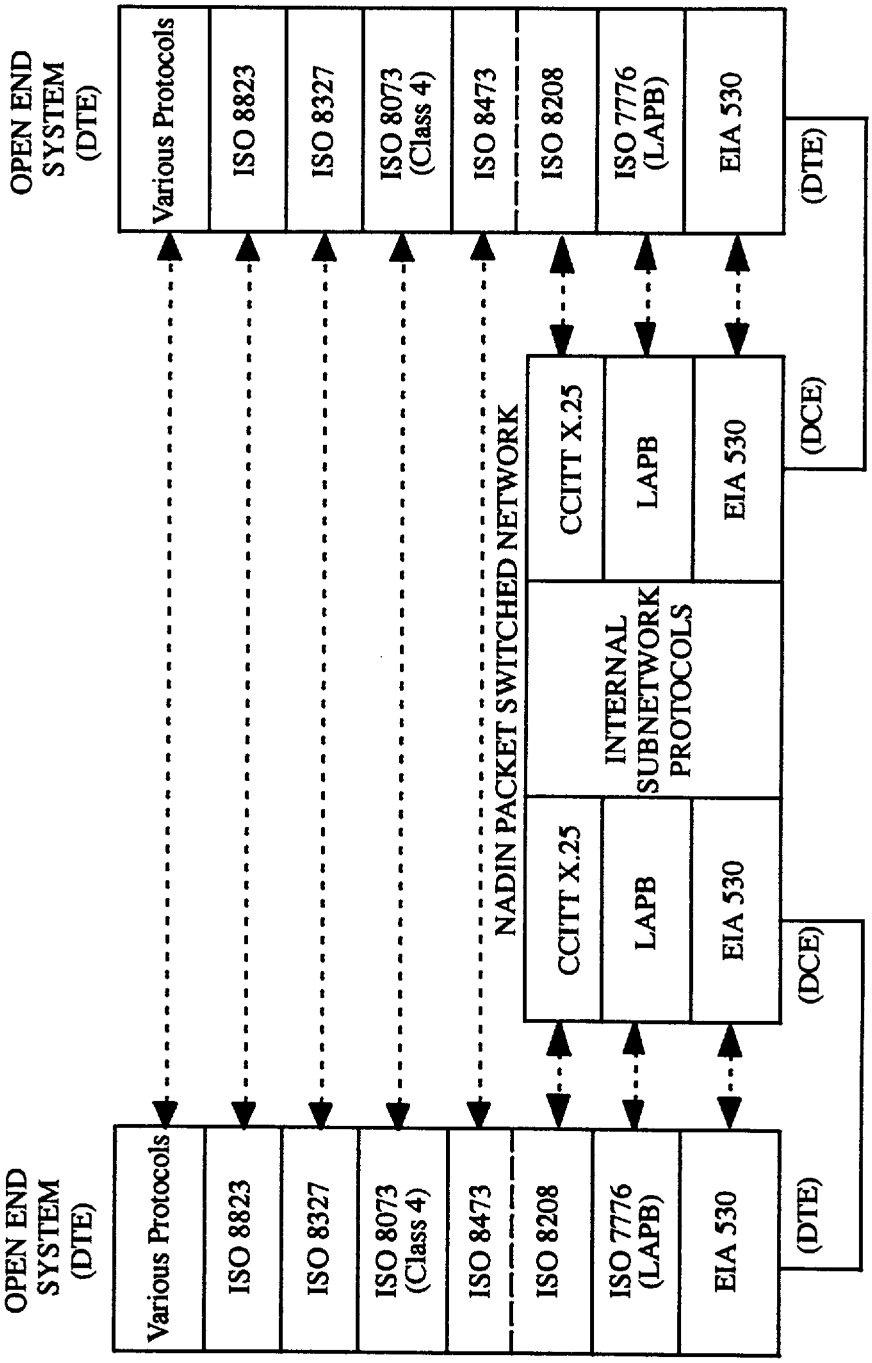

FIGURE 2 Standard Protocols for NAS Open Systems Communicating via Wide Area Networks (e.g., NADIN PSN)

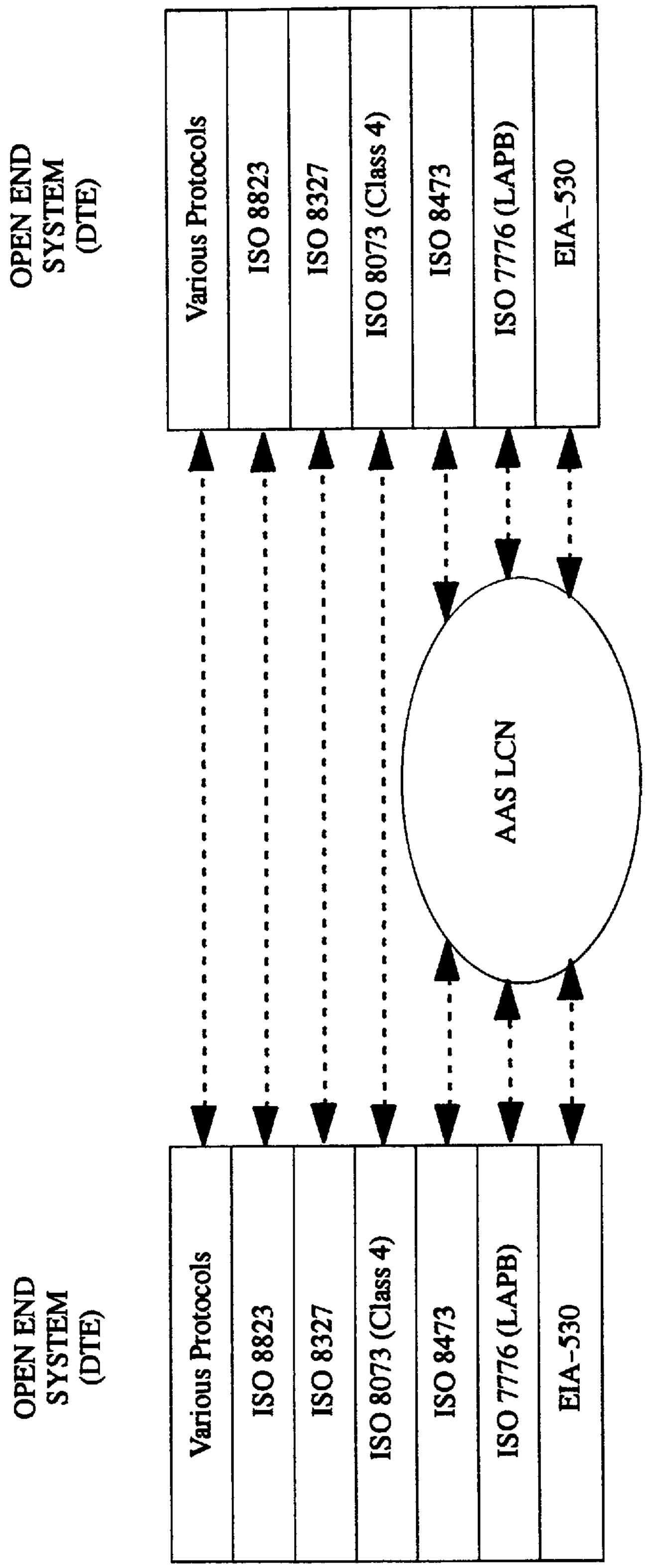

FIGURE 3 Standard Protocols for NAS Open Systems Communicating via AAS LCN

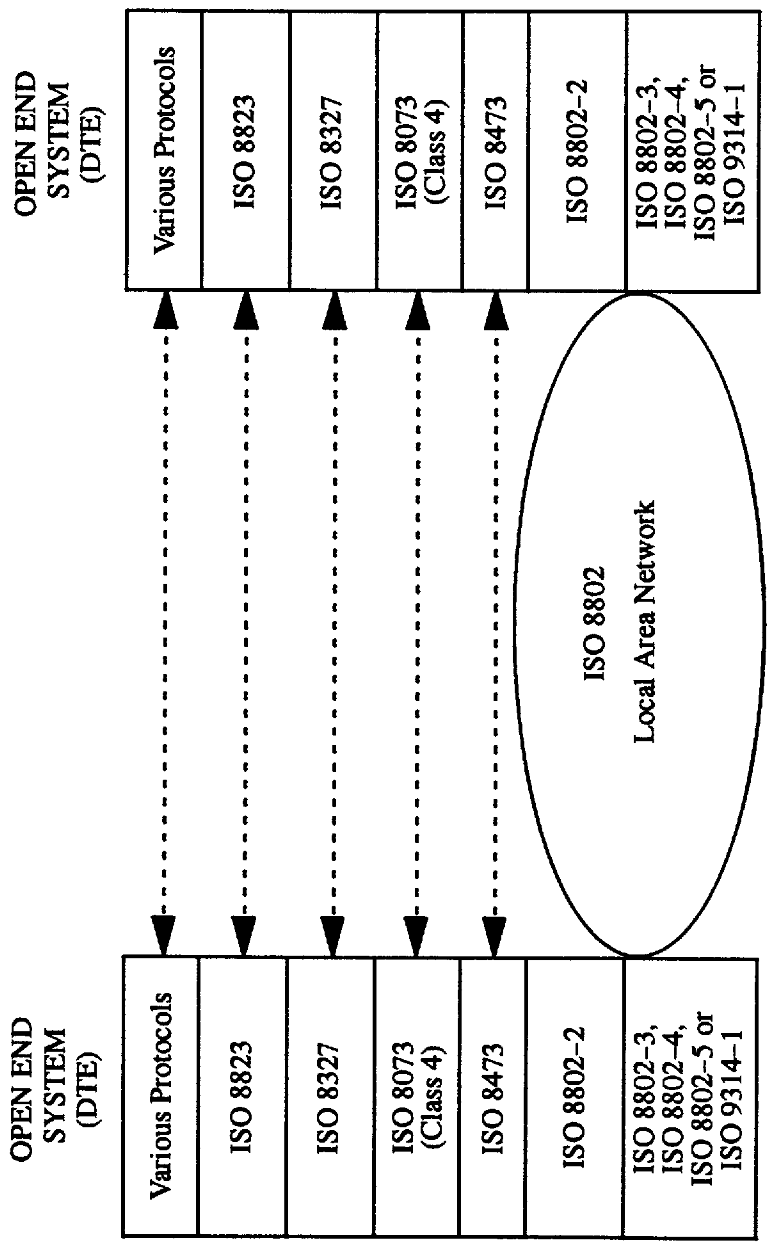

FIGURE 4 Standard Protocols for NAS Open Systems Communicating via LANs (Except AAS LCN)

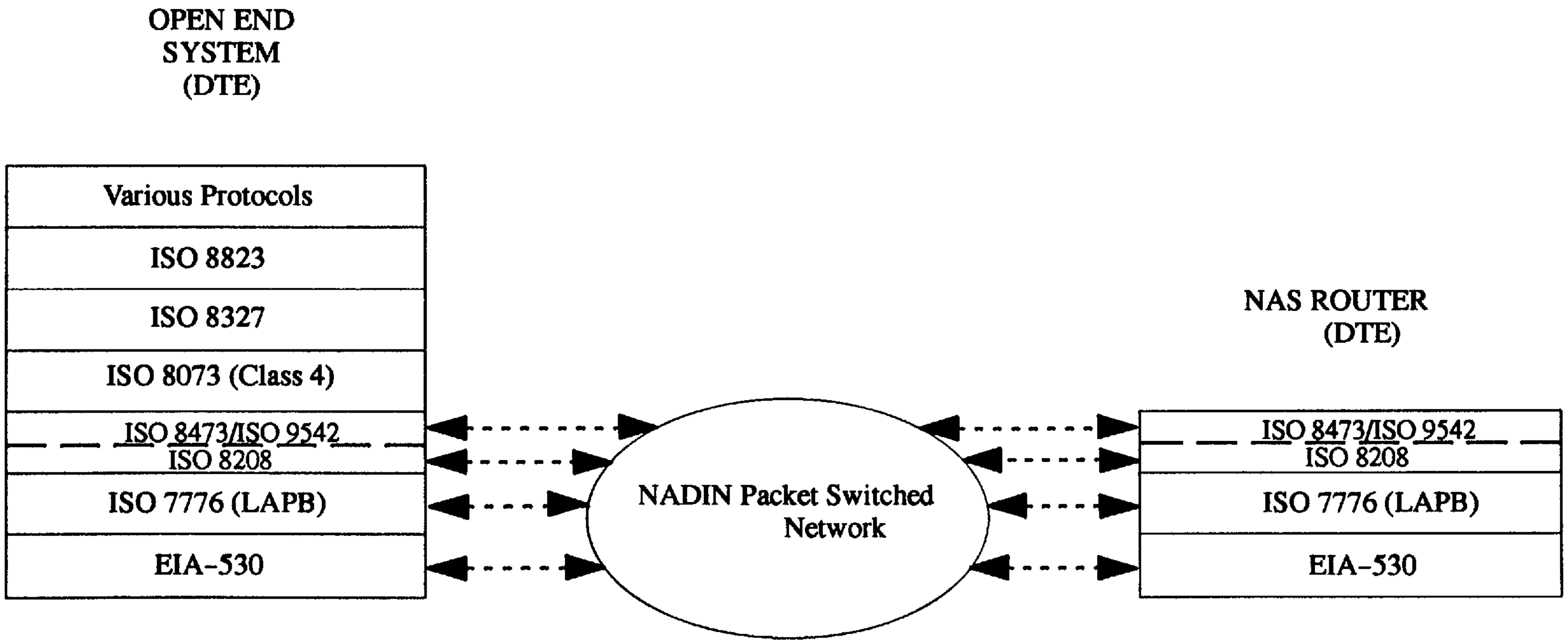

FIGURE 5 Standard Protocols for Communicating Between NAS Open End System and NAS Router via Wide Area Network (e.g., NADIN PSN)

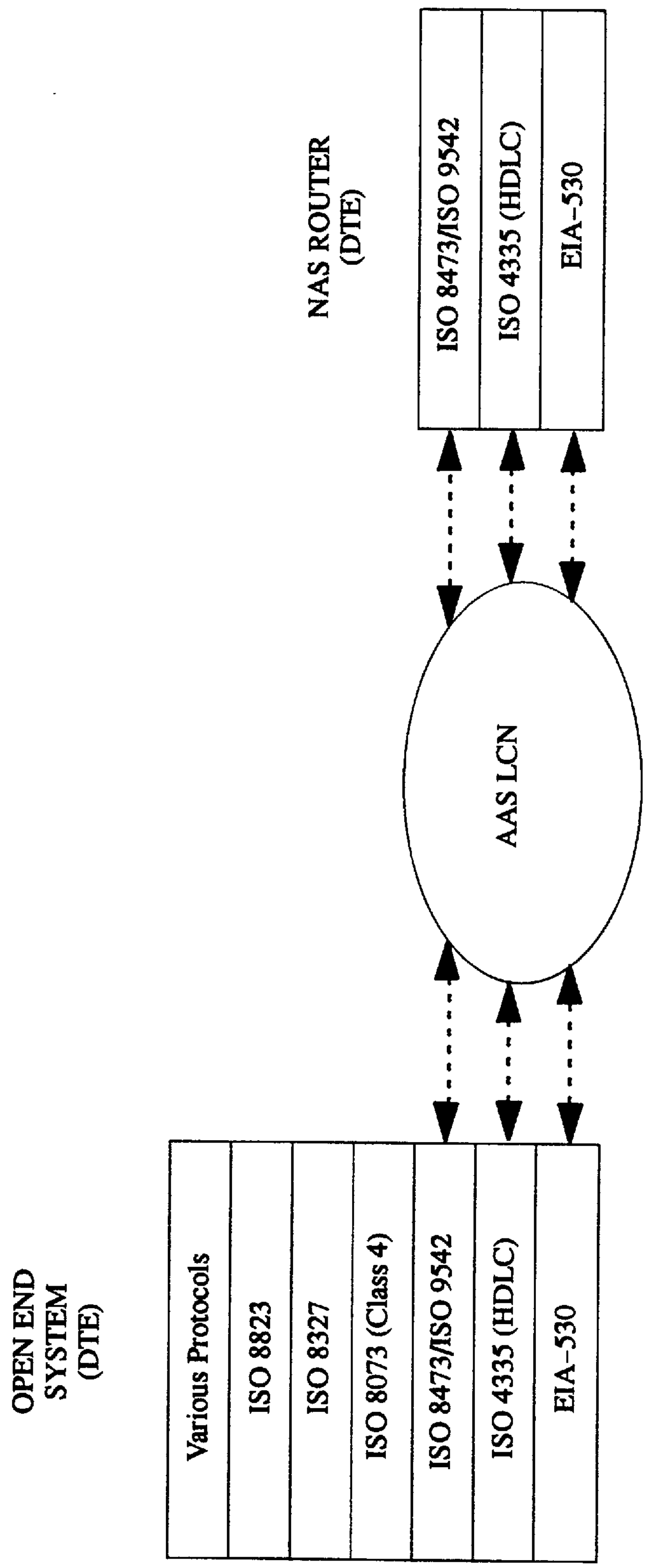

FIGURE 6 Standard Protocols for Communicating Between NAS Open End System and NAS Router Communication via AAS LCN

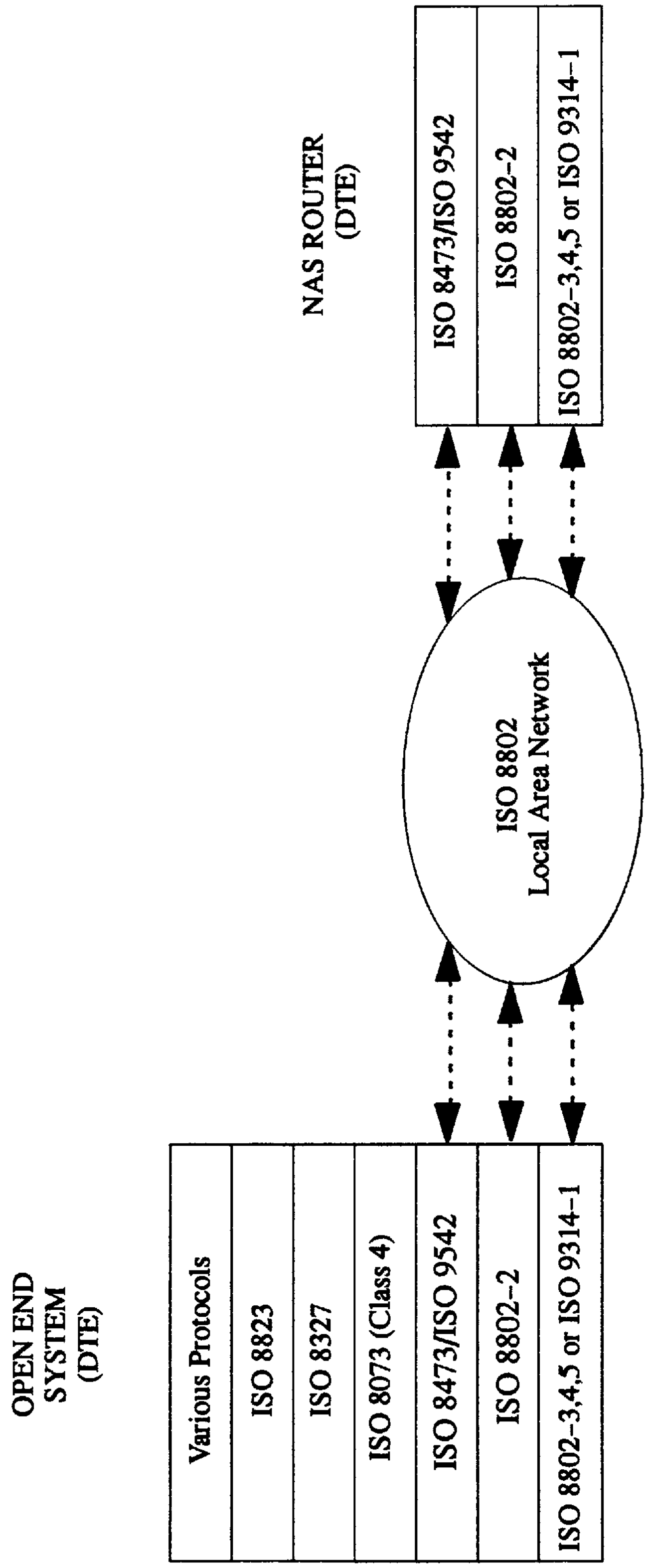

FIGURE 7 Standard Protocols for Communicating Between NAS Open End System and NAS Router Communication via LANs (Except AAS LCN)

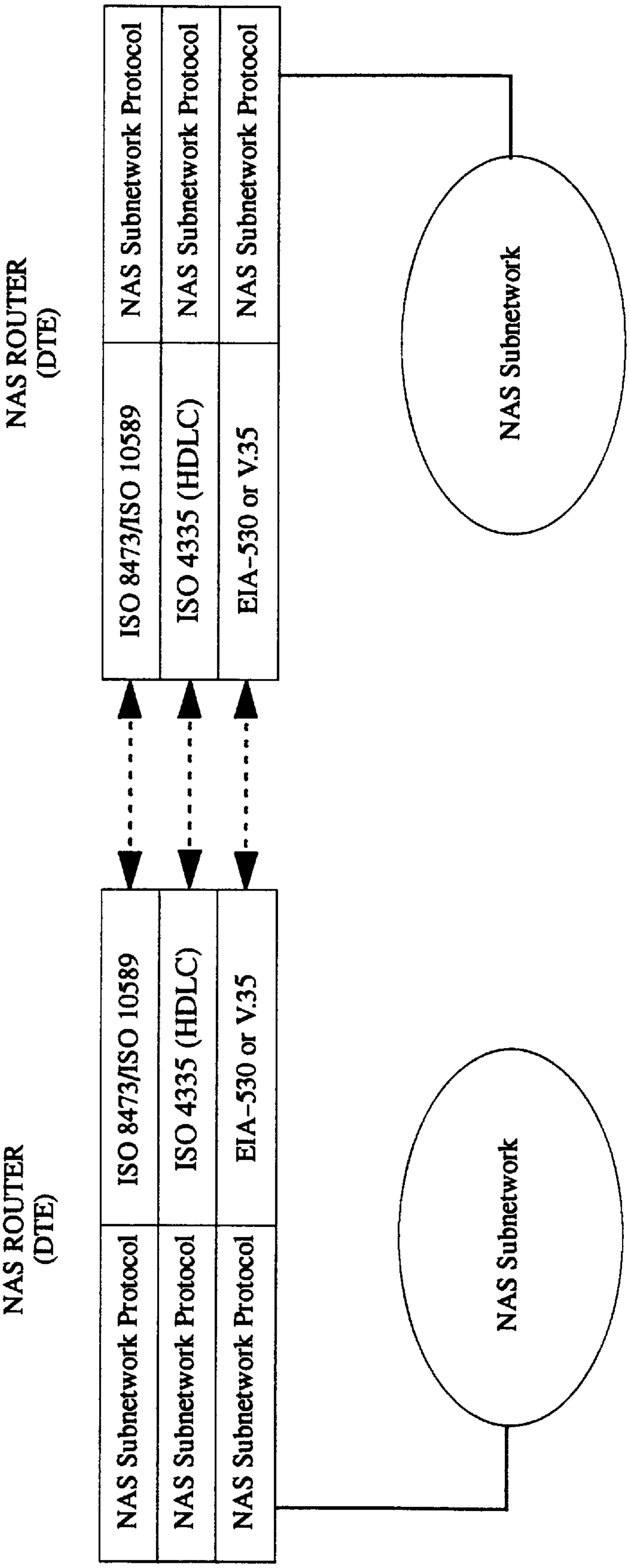

FIGURE 8 Standard Protocols for Communicating Between NAS Router and NAS Router

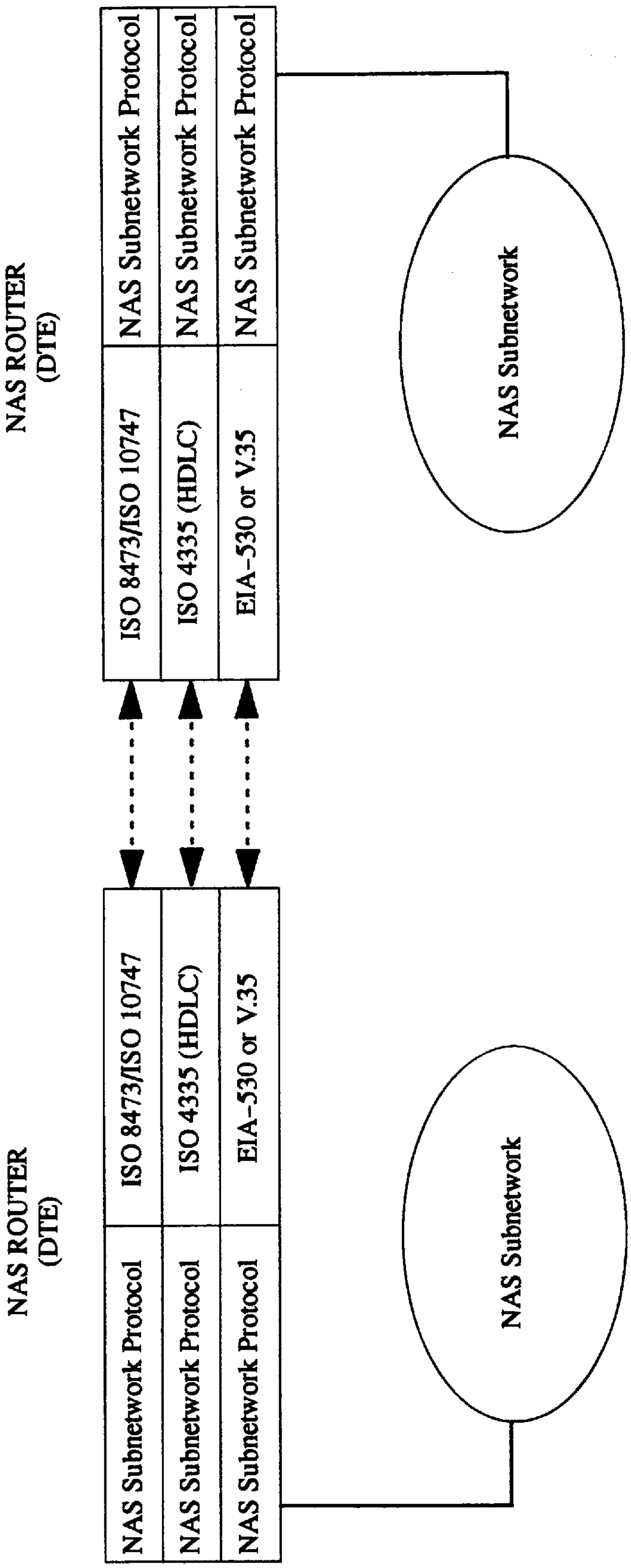

FIGURE 9 Standard Protocols for Communicating Between NAS BIS Router and Non-NAS BIS Router

3.2.1.1 Application Layer Protocol Standards. This section describes the Application Layer protocols selected for use by NAS open end-systems.

3.2.1.1.1 Function of Application Layer Protocols. The Application Layer allows for functions and services required by particular user-designed application processes. Functions satisfying particular user requirements are contained in this layer. Representation and transfer of information necessary to communicate between applications are the responsibility of the lower layers. The Application Layer functions are provided by application service elements (ASE). ISO 9545, Application Layer Structure, defines the nature of ASEs, the relationships among them, and the architectural framework in which individual OSI compliant Application Layer protocols are developed.

3.2.1.1.2 Application Layer Protocol Specification. NAS open end-systems will use common application service elements (ASE) to provide application layer services common to users applications. These ASEs include Association Control Service Element (ACSE) and Remote Operations Service Element (ROSE). NAS open end-systems may select from several specific ASEs to satisfy particular open end-system requirements. These ASEs include File Transfer, Access, and Management (FTAM), Message Handling System (MHS), Transaction Processing (TP), and Virtual Terminal (VT).

3.2.1.1.2.1 Association Control Service Element (ACSE). All NAS open end-systems shall implement the service of ACSE as defined in ISO 8649 and the protocol as defined in ISO 8650. The ACSE has two classes of service: Class 1 and Class 2. Class 1 consists of association control and information transfer facilities for operation in a known context. Class 2 consists of all Class 1 service elements, plus the mandatory service elements of the context management facility. The ACSE facilities are specified as follows:

(a) The association control facility is provided to initiate, maintain, and release an association between two application entities. It provides service elements to originate a new application association, including defining the application context and initiating a presentation connection.

(b) The information transfer facility is a set of application service elements that transfer information between associated application entities.

(c) The context management facility negotiates the sets of service elements to be used during the lifetime of the application association and allows switching between agreed contexts.

NAS open end-systems shall implement the association control and information transfer facilities at a minimum. They shall support Class 1 or 2 as required.

3.2.1.1.2.2 Remote Operations Service Element. ROSE, which is used in conjunction with other ASEs, defines the services and notations necessary to support interactive applications between distributed processing systems. NAS open end-system shall implement ROSE in accordance with ISO 9072-1, ISO 9072-2, and the NIST Stable Implementation Agreements for Open Systems Interconnection Protocols.

3.2.1.1.2.3 File Transfer, Access, and Management. NAS file transfer applications between open end-systems shall use FTAM. NAS open end-system FTAM implementations shall be in accordance with ISO 8571-1, ISO 8571-2, ISO 8581-3, ISO 8571-4, and the NIST Stable Implementation Agreements for Open Systems Interconnection Protocols.

3.2.1.1.2.4 Message Handling System. NAS electronic mail applications between open end-systems shall use MHS. NAS open end-system MHS implementations shall be in accordance with ISO 10021-1, 10021-2, 10021-3, 10021-4, 10021-5, 10021-6, 10021-7, and the NIST Stable Implementation Agreements for Open Systems Interconnection Protocols.

3.2.1.1.2.5 Transaction Processing. NAS open end-system applications requiring interactive update of files, in which results are generated immediately after data entry, shall use TP. NAS open end-system TP implementations shall be in accordance with ISO 10026-1, ISO 10026-2, 10026-3 and the NIST Stable Implementation Agreements for Open Systems Interconnection Protocols.

3.2.1.1.2.6 Virtual Terminal. NAS open end-system applications requiring simple line at a time or character at a time dialogue shall use VT. NAS open end-system VT implementations shall be in accordance with ISO 9040, ISO 9041-1, and the NIST Stable Implementation Agreements for Open Systems Interconnection Protocols.

3.2.1.2 Presentation Layer Protocol Standards. This section describes the Presentation Layer protocols selected for use by NAS open end-systems.

3.2.1.2.1 Function of Presentation Layer Protocols. The Presentation Layer provides services that determine how all data exchanged by its users (i.e., by application entities) will be represented while in transit across the network. A common meaning is provided through the use of a common transfer syntax between different end-systems. This common syntax is used to represent information including character codes, data types, and file formats.

The Presentation Layer protocol acts as an arbitrator, negotiating a common transfer syntax to be used for the representation of information that the application processes will exchange.

Presentation Layer services include the management of data entry, exchange, display, and representation between application entities. The meaning (semantics) of the data is maintained, while the format and language differences (syntax) are resolved.

The connection-oriented presentation service is defined in ISO 8822. The connection-oriented presentation protocol specification is defined by ISO 8823 and consists of two functional units: kernel and context management.

The kernel is mandatory and is always available for service. It supports the presentation connection and the transfer of data. It also negotiates for the use of one or more transfer syntaxes. Transfer syntaxes may make use of data compression techniques such as run-length encoding.

Context management is an optional service and is negotiable at the time of connection. It allows presentation contexts to be added or deleted during the lifetime of a presentation connection. All new presentation contexts are added to a defined context set.

3.2.1.2.2 Presentation Layer Protocol Specification. NAS open end-systems shall implement the connection-oriented presentation service as defined in ISO 8822 and the connection-oriented presentation protocol as defined in ISO 8823.

At a minimum, NAS open end-systems shall implement the presentation kernel. Context management is optional, and shall be used only if needed by particular interfaces.

The Application Layer defines the syntax of messages by using a formal description language called Abstract Syntax Notation One (ASN.1). The abstract syntax used by NAS open end-systems shall be in accordance with ISO 8824 (ASN.1). The transfer syntaxes used by NAS open end-systems shall be encoded in accordance with ISO 8825 (Basic Encoding Rules for ASN.1). These rules include coding rules for integers, floating point, octet strings, time data, etc. The minimum transfer syntax shall be OCTET STRING, primitive encoding, with pre-agreed upon syntax. Other transfer syntaxes may be defined at a later date for special purposes.

3.2.1.2.3 Session Layer Protocol Standards. This section describes the Session Layer protocols selected for use by NAS open systems.

3.2.1.2.3.1 Function of Session Layer Protocols. The Session Layer allows cooperating application entities to organize and synchronize conversation and to manage data exchange. To transfer data, session connections use transport connections. During a session between application entities, Session Layer services are used to regulate dialogue by ensuring an orderly message exchange on the session connection.

The structured aspects of session dialogue include protocols for turn to talk, for how long to talk, and communications mode (i.e., full duplex or half duplex). Additional functions are establishment of major and minor synchronization points, mapping of names to addresses, reporting of error conditions, and splitting of dialogue into logical activities that are managed on a session basis.

The session service operates in one of three distinct phases:

(a) Connection Establishment Phase -- Cooperating users are identified and the facilities (tokens) and parameters to be used during the session are negotiated.

(b) Data Transfer Phase -- Normal and expedited classes of data exchange are provided, supported by token management, session synchronization, and exception reporting facilities.

(c) Connection Release Phase -- Services are provided for orderly release, user-initiated (presentation) abort, and provider (session) abort. The latter two cases may result in the loss of some protocol data units.

3.2.1.2.3.2 Session Layer Protocol Specification. NAS open end-systems shall implement the connection-oriented session service as defined in ISO 8326 and the connection-oriented session protocol specification as defined in ISO 8327. The Session Version 2 (Unlimited User Data) shall be supported in accordance with ISO 8326/DAD2 and ISO 8327/DAD2. The session protocol consists of a kernel, and 11 other functional units. These functional units may be used in various combinations, depending on the required functions. The set of functional units to be implemented is determined by the requirements of the Application Layer protocol. At a minimum, NAS open end-systems shall implement the kernel and full-duplex functional units. Certain applications may require the implementation of additional functional units.

3.2.2 Lower-layers. Layers 1, 2, and 3 of the OSI Reference Model (Physical, Data Link, and Network) are responsible for the data communication protocols used to interface the data communications network with the communicating NAS end-system processors. Layer 4 of the OSI Reference Model (Transport Layer), isolates the upper-layers from the detailed workings of the lower-layers. This section describes the protocols selected for NAS open end-system implementation of the OSI lower-layers.

3.2.2.1 Transport Layer Protocol Standards. This section describes the Transport Layer protocols selected for use by NAS open end-systems.

3.2.2.1.1 Function of Transport Layer Protocols. The Transport Layer provides reliable, transparent transfer of data between cooperating session entities. The Transport Layer entities optimize the available network services to provide the performance required by each session entity. Optimization is constrained by the overall demands of concurrent session entities and by the quality and capacity of the network services available to the Transport Layer entities. Transport protocols regulate flow, detect and correct errors, and multiplex data, on an end-to-end basis.

To provide a basis for deciding which Transport Layer protocol should be used, three types of Network Layer connections have been defined regarding error rates in relation to user requirements. Type A network connections have an acceptable residual (unsignaled) error rate and an acceptable signaled error rate. Type B network connections have an acceptable residual (unsignaled) error rate and an unacceptable signaled error rate. Type C network connections have an unacceptable residual (unsignaled) error rate. An important point is that acceptability is determined relative to the needs of the applications, rather than being an absolute measure.

3.2.2.1.2 Transport Layer Protocol Specification. There are two types of Transport Layer services: Connection-Oriented and Connectionless. NAS open end-systems shall implement the Connection-Oriented Network Service (CONS).

3.2.2.1.2.1 Connection-Oriented Transport Service. NAS open end-systems shall implement the connection oriented transport service as defined in ISO 8072 and the protocol as defined in ISO 8073 and ISO 8073/AD2. The connection-oriented protocol is divided into five classes (0 through 4):

(a) Class 0 - Simple Class -- This class is designed to be used with Type A network connections. It is the simplest type of transport connection. It provides neither error recovery nor multiplexing (e.g., systems with a requirement for X.400 mail systems shall support Class 0).

(b) Class 1- Basic Error Recovery Class -- This class is designed to be usedwith Type B network connections. It provides a basic transport connection with minimal overhead. Recovery from network disconnect or reset is included.

(c) Class 2 - Multiplexing Class -- This class is designed to be used with Type A network connections. It multiplexes several transport connections onto a single network connection. There is no error detection or recovery procedure. The transport connection is terminated when an error is signaled from the Network Layer.

(d) Class 3 - Error Recovery and Multiplexing Class -- This class is designed to be used with Type B network connections. It provides the multiplexing capabilities of Class 2 with the error recovery capabilities of Class 1.

(e) Class 4 - Error Detection and Recovery Class -- This class is designed to be used with Type C network connections. It provides the characteristics of Class 3, and the capability to detect and recover from lost, duplicated, or out-of-sequence transport protocol data units (TPDU). It also provides the optional detection of damaged TPDUs by use of a checksum. It allows for increased throughput by permitting a transport connection to use multiple network connections.

NAS open end-systems shall implement ISO 8073, Class 4, and shall comply with the transport procedures stated in the Stable Implementation Agreements for OSI protocols.

3.2.2.1.2.2 Connectionless Transport Service. Although ISO has defined a connectionless (datagram) transport protocol (ISO 8602), there are currently no NAS open end-systems requirements specified for its use.

3.2.2.2 Network Layer Protocol Standards. This section describes the Network Layer protocols selected for use by NAS open systems.

3.2.2.2.1 Function of Network Layer Protocols. The Network Layer provides functions for the relaying and routing of information between OSI users on end-systems which may or may not be connected by intermediate systems. End-systems and intermediate systems provide the same Network Layer functions, with the exception of relaying functions which are performed by intermediate systems only. The Network Layer provides hop-by-hop network service enhancements, flow control, and load leveling. Services provided by this layer are independent of the distance separating interconnected networks. The Network Layer shall be structured in accordance with ISO 8648, Internal Organization of the Network Layer.

3.2.2.2.2 Network Layer Protocol Specification. NAS open systems shall support the Connectionless-Mode Network Service (CNLS) and the Connection-Oriented Network service (CONS) as defined in ISO 8348, ISO 8348/AD1, and ISO 8473.

NAS open end-systems communicating over packet switching networks (e.g., NADIN PSN) shall implement ISO 8208 as the subnetwork access protocol whether implementing CLNS or CONS. ISO 8208 will provide for direct layer 3 connections between open end-systems (DTE to DTE) as well as connections through an intermediate system such as a packet switching network (DTE to DCE) Intermediate systems shall implement CCITT X.25 (1984) provided they correctly interface to end-systems implementing ISO 8208.

3.2.2.2.2.1 Connectionless-Mode Network Service (CLNS). The CLNS provides the Transport Layer with a connectionless network service where network connections between end-systems are not established. Information is transferred via individual data unit transfers which are independent of previous transfer requests. All NAS open end-systems and intermediate systems shall implement ISO 8348/AD1, Network Service Definition, Addendum 1: Connectionless Mode Transmission.

3.2.2.2.2.1.1 Connectionless Network Protocol Functions. All NAS open end-systems shall implement ISO 8473, Protocol for Providing the Connectionless-Mode Network Service. A subset of the Full Protocol (see Table 4 of ISO 8473) shall be supported utilizing the following protocol functions: (See Clauses 6.1 through 6.18 and Table 4 of ISO 8473 for a description of the functions)

(a) Type 1 functions: All Type 1 functions are mandatory under the standard.

(b) Type 2 functions: Type 2 functions are optional.

(c) Type 3 functions: The following Type 3 functions shall be supported:

(1) Priority

(2) Quality of Service

3.2.2.2.2.1.2 Provision of the Underlying Service. NAS open end-systems shall provide the subnetwork dependent convergence function as specified in ISO 8473 - clause 8.5.2. The convergence function will map the connectionless services of the Network Layer to the services provided by the X.25 connection-oriented network access protocol. ISO 8473/AD3 shall be implemented for open end-systems providing ISO 8473 over an OSI data link service.

3.2.2.2.2.1.3 Provision for Routing Protocols. NAS open end-systems, requiring communications via routers, shall implement the End System (ES) to Intermediate System (IS) Routing Protocol in conjunction with ISO 8473. NAS intermediate systems providing NAS routing shall implement shall implement the IS to IS Intra-Domain Routing Protocol. NAS intermediate systems providing routing to external networks shall use the Boundary Intermediate System (BIS) Inter-Domain Routing Protocol.

3.2.2.2.2.1.3.1 End System to Intermediate System Routing Protocol. NAS open end-systems, that require communication through routers, shall use the ES-IS routing protocol to enable routing service. The ES-IS protocol shall be in accordance with ISO 9542 and the OIW Stable Agreement for Open Systems Interconnection Protocols and shall be used in conjunction with ISO 8473.

3.2.2.2.2.1.3.2 Intermediate System to Intermediate System Intra-Domain Routing Protocol. NAS open intermediate systems, providing NAS routing, shall use the IS-IS intra-domain routing protocol to enable routing within the NAS routing domain. The IS-IS protocol shall be in accordance with ISO 10589 and the NIST Stable Agreement for Open Systems Interconnection Protocols and shall be used in conjunction with ISO 8473. Intra-domain routing between the NAS and the ATN shall be in accordance with the ATN Manual.

3.2.2.2.2.1.3.3 Boundary Intermediate System to Boundary Intermediate System Inter-Domain Routing Protocol. NAS open boundary intermediate systems, providing routing, shall use the BIS-BIS inter-domain routing protocol to enable routing between the NAS routing domain and an external routing domain (e.g., ATN routing domain). The BIS-BIS protocol shall be in accordance with ISO 10747 and the NIST Stable Agreement for Open Systems Interconnection Protocols and shall be used in conjunction with ISO 8473. Inter-domain routing between the NAS and the ATN shall be in accordance with the ATN Manual.

3.2.2.2.2.2 Connection-Oriented Network Service (CONS). The CONS provides the Transport Layer with a network connection service where network connections between end-systems are to be established. CONS shall be implemented in accordance with ISO 8880-1 and ISO 8880-2. CONS may be used over a specific interface provided there are either no intermediary networks or only X.25 intermediary networks. For NAS open end-systems communicating over X.25 wide area networks, CONS shall be provided as defined in ISO 8878, Use of X.25 to Provide OSI Connection-mode Network Service.

3.2.2.2.2.2.1 Optional User Facilities (for X.25 subnetworks). X.25 supports a wide variety of features and options called facilities. The following optional user facilities shall be supported by the X.25 subnetwork (e.g., NADIN PSN) in accordance with CCITT X.25 (1984). The X.25 subnetwork shall provide the facility if requested by the end-system.

(a) On-line facility registration;

(b) Extended packet sequence numbering;

(c) Nonstandard default window sizes;

(d) Default throughout classes assignment;

(e) Incoming calls barred;

(f) Outgoing calls barred;

(g) One-way logical channel incoming;

(h) One-way logical channel outgoing;

(i) Closed user group;

(j) Closed user group with outgoing access;

(k) Closed user group with incoming access;

(l) Reverse charging acceptance;

(m) Nonstandard default packet sizes;

(n) Flow control parameter negotiation;

(o) Throughput class negotiation;

(p) Fast select acceptance;

(q) D-bit modification;

(r) Call redirection;

(s) Hunt group.

The following optional facilities shall be provided by the X.25 subnetwork when requested by the end-system on a per-call basis:

(a) Fast select;

(b) Closed user group selection;

(c) Reverse charging;

(d) Registered Private Operating Agency (RPOA);

(e) Flow control parameter negotiation;

(f) Throughput class negotiation;

(g) Called line address modified notification;

(h) Call redirection notification;

(i)(Network user identification.

In addition, the X.25 subnetwork shall support CCITT-specified DTE facilities as described in Annex G of the X.25 Recommendation.

3.2.2.2.2.2.2 Optional User Facilities (for ISO 8208 systems). NAS open end-systems implementing the CONS shall support the following optional user facilities in accordance with Clause 5.1 ISO 8878:

(a) Fast select;

(b) Fast select acceptance;

(c) Throughput class negotiation;

(d) Transit delay selection and indication;

(e) Called address extension;

(f) Calling address extension;

(g) End-to-end transit delay negotiation;

(h) Expedited data negotiation;

(i) Minimum throughput class negotiation.

This standard does not require or prohibit use of other X.25 facilities by NAS open end-systems. The facilities used will vary among different interfaces.

3.2.2.3 Data Link Layer Protocol Standards. This section describes the Data Link Layer protocols selected for use by NAS open systems.

3.2.2.3.1 Function of Data Link Layer Protocols. The Data Link Layer provides services related to the reliable interchange of data without loss across a physical link between adjacent systems. Data link protocols manage the logical establishment, maintenance, and release of data link connections. In addition, these protocols control the synchronization and flow of data, and supervise error recovery. The Data Link Layer functions are provided as services to the Network Layer. In bit-oriented protocols, the detection of transmission errors is typically accomplished through a cyclic redundancy check (CRC) algorithm. The data stream is broken down into the basic transmission units (data frames). The Data Link Layer protocols may provide mechanisms to handle lost, damaged, or duplicate data frames, acknowledgment of receipt of current data frames, line turn-around, and basic flow control.

3.2.2.3.2 Data Link Layer Protocol Specification. The Data Link Layer protocol standards implemented by NAS open systems shall be ISO 4335, ISO 7478, CCITT X.32, and ISO 8802-2.

3.2.2.3.2.1 High-level Data Link Control (HDLC) ISO 4335. NAS open systems shall implement the Data Link Layer service as defined in ISO Draft International Standard (DIS) 8886 and the protocol as defined in ISO 4335 (HDLC). ISO standards 3309 (HDLC frame structure) and 7809 (HDLC consolidation classes of procedure) are also applicable. The options recommended for use by NAS open systems are described below:

(a) Option 2 - Reject -- This option is required by ISO 7776 [Link Access Procedure Balanced (LAPB)] and permits the prompt initiation of the recovery process for missing information frames (I-frame) by providing for a negative acknowledgment (reject).

(b) Option 3 - Selective Reject -- This option allows requesting retransmission of a single I-frame and recovers I-frame sequence errors. It may improve efficiency on links with long transmission delay (e.g., satellite links or systems using modulo 128).

(c) Option 4 - Unnumbered Information Frames -- This option provides ability to exchange information without impacting the send and receive variables. This option allows datagram transmission (i.e., transmission with no acknowledgment of receipt).

(d) Option 7 - Multiple Octet Addressing -- This option allows the use of one or more address octets. It allows multiple octet addresses and therefore allows more address combinations. Note that multiple octet addresses are not required.

(e) Option 8 - I-Frames Transmitted Only as Commands -- This option is required by ISO 7776 (LAPB) and is required to achieve greater compatibility, particularly for NADIN PSN interfaces (which must comply with this for proper operation).

(f) Option 10 - Extended Sequence Numbering -- This option allows sequence numbers to be extended from modulo 8 to modulo 128. This option can improve efficiency on links with long transmission delay (e.g., satellite links), especially if used in conjunction with option 3.

(g) Option 12 - Data Link Test -- This option enable performance of Data Link Layer loopback tests.

The HDLC normal response mode (NRM) shall be used in cases where multi-drop or polling systems are used and the use of the standard seven layer protocol architecture is inappropriate or special options are required.

3.2.2.3.2.1.1 CCITT X.25 LAPB. The standard NAS open systems implementation for X.25 intermediate systems shall be balanced asynchronous [Class Balanced Asynchronous (BA)] with options 2 and 8. Class BA with options 2, 8, and 10 is recognized as an optional, subscription-time selectable, extended sequence numbering service that may be available to serve DTE applications having a need for modulo 128 sequence numbering.

3.2.2.3.2.1.2 ISO 7776. ISO 7776 shall be used by X.25 DTEs to insure a compatible LAPB interface to the DCE.

3.2.2.3.2.2 ISO 7478 (Multilink Procedure). NAS open end-systems required to transfer data over multiple parallel physical connections to achieve a reliable, available, and variable bandwidth between the DTE/DCE interface shall implement the multilink procedure (MLP) in accordance with ISO 7478. The MLP function resides as an upper sub-layer of the Data Link Layer. It operates between the multiple single data link protocol functions and the Network Layer. X.25 users shall implement MLP as a subscription time option as described in section 2.5 (LAPB) of CCITT Recommendation X.25, 1984 version. The implementation of MLP in the NAS shall facilitate the mitigation of a critical path failure without the interruption of services and shall:

(a) Achieve economy and reliability of service by providing multiple physical connections between the DTE and DCE interface;

(b) Permit addition and deletion of single physical connections without interrupting the services provided by the multiple connections;

(c) Optimize bandwidth use of a group of connections through load sharing;

(d) Achieve graceful degradation of service when a single connection or multiple connections fail;

(e) Provide each group with the appearance of a single logical data link to the Network Layer;

(f) Provide, when required, resequencing of the received data units before to delivery to the Network Layer;

(g) Minimize the impact that multilink operation may have on the Network Layer protocols and existing data links;

(h) Maximize the applicability of the procedure to a variety of link control protocols, line speeds, and configurations.

The MLP link control functions, link layer addressing, frame structure, and link parameters shall be implemented in accordance with ISO 7478 [CCITT X.25 (1984) for X.25 users].

3.2.2.3.2.3 CCITT X.32. Dial-in/dial-out services and procedures shall be implemented in accordance with CCITT X.32 when the packet switching network uses a public telephone network as its backbone.

3.2.2.3.2.4 ISO 8802-2. NAS open systems shall implement ISO 8802-2 as the standard for logical link control (LLC) in conjunction with ISO 8802-3, 8802-4, or ISO 8802-5. Either connectionless or connection-oriented operations shall be supported.

3.2.2.4 Physical Layer Protocol Standards. This section describes the Physical Layer protocol standards selected for use by NAS open end-systems.

3.2.2.4.1 Function of Physical Layer Protocol Standards. As the lowest layer in the OSI Reference Model, the Physical Layer interface provides services to the next higher layer, the Data Link Layer. It is responsible for establishing the physical connection and interface to the transmission medium [e.g., Data Terminal Equipment (DTE)/Data Circuit-Terminating Equipment (DCE) interface]. The characteristics of this layer are independent of the physical media, which could be coaxial cable, twisted copper wire, fiber optic cable, and many other cable types. The Physical Layer interface is concerned primarily with the following physical interface characteristics:

(a) Mechanical: This characteristic defines the physical attributes of the connector (i.e., the number of pins, shape, and dimensions of the connecting block).

(b) Electrical: This characteristic specifies whether the connection is balanced or unbalanced and what voltages are to be used.

(c) Functional: This characteristic defines which electrical circuit performs control, timing, and grounding.

3.2.2.4.2 Physical Layer Protocol Specification. NAS open systems shall implement one of the following standards at the physical layer interface: EIA-530, EIA-232E, RS-232C, V.35, V.32, ISO 8802-X, AND ISO 9314 (FDDI).

3.2.2.4.2.1 EIA-530. EIA-530 shall be the primary Physical Layer interface standard implemented by new systems. EIA-530 has the following interface characteristics:

(a) Data rate: Lines speeds between 0 to 2 Mbps are supported in accordance with FIPS PUB 154.

(b) Cable length: Cable lengths up to 200 feet (maximum) are supported for high-speed lines. Cable lengths up to 4000 feet (maximum) are supported for low-speed lines (0 to 20 kbps).

(c) Mechanical: D-shaped, 25-pin interface connector is specified for all interchange circuits in accordance with ISO 2110. The DTE requires male (pin) contacts and a female shell (plug connector); the DCE requires a female contacts and a male shell.

(d) Electrical: The maximum voltage is +/- 6V. The balanced electrical characteristics are defined in RS-422A and FED-STD-1020A (EIA-530, Category I). The unbalanced electrical characteristics are defined in RS-423A and FED-STD-1030A (EIA-530, Category II).

(e) Functional: EIA-530 interchange circuits fall into four general classifications: ground (or common return), data circuits, control circuits, and timing circuits. A functional description of the interchange circuits, pin assignments, and selected communication system configurations are specified in EIA-530 (FED-STD-1032 and FIPS PUB 154).

The additional functions [local loopback (LL), remote loopback (RL), and test mode (TM)] shall assist users in tracking down a defective unit and fault isolation between DTE/DCE.

EIA-530 will not interoperate with equipment using RS-232 electrical characteristics. EIA-530 does not support secondary signals and dial-up applications.

3.2.2.4.2.2 EIA-232E. EIA-232E shall be used by NAS interfaces that are required to implement dial-up applications and secondary signals. This standard is a revision of RS-232C and EIA-232D. This revision updates the standard to conform to CCITT V.24 (modem connection to the telephone network), V.28, and ISO 2110. It also includes the specification for a 25-pin interface connector and adds LL, RL, and TM interchange circuits. A shield has been added, the protective ground has been redefined, and some terminology has been changed. EIA-232E is compatible with the electrical characteristics of EIA-232D but not with EIA-530. EIA-232E is compatible with the electrical characteristics of EIA-232C but has additional functionality. EIA-232E has the following interface characteristics:

(a) Data rate: Low-speed lines up to 20 kbps are supported.

(b) Cable length: Cable lengths up to 50 feet (maximum) are supported for low-speed lines. When more than 50 feet of cable is required, a low capacitance, shielded cable is recommended in accordance with EIA-232E.

(c) Mechanical: D-shaped, 25-pin interface connector is specified for all interchange circuits in accordance with ISO 2110.

(d) Electrical: The operating voltage range is +/- 3V to +/- 25V, unbalanced. Unbalanced circuits (each circuit uses only one pin and a common ground return) are defined in the EIA-232D standard. Electrical signal characteristics are defined in CCITT V.28 and the EIA-232D standard.

(e) Functional: Synchronous/asynchronous and full/half duplex communications are supported via the interchange circuits and pin assignments as defined in CCITT V.24 and the EIA-232D standard.

3.2.2.4.2.3 RS-232C. RS-232C shall be supported for interfacing with existing NAS interfaces. RS-232C is a part of CCITT recommendation X.21 bis and is used for low-speed data communications.

(a) Data rate: Low-speed lines of 20 kbps or less are supported.

(b) Cable length: Cable lengths up to 50 feet (maximum) are supported.

(c) Mechanical: The 25-pin connector is defined in an appendix of the RS-232C standard.

(d) Electrical: Unbalanced circuits (each circuit uses only one pin and a common ground return) are defined in the RS-232C standard. Electrical signal characteristics are defined in the RS-232C standard.

(e) Functional: Synchronous/asynchronous and full/half duplex communications are supported via the interchange circuits and pin assignments as defined in the RS-232C standard.

3.2.2.4.2.4 V.35. V.35 is a CCITT recommendation for data transmission on wide band group channels. This standard shall be used by NAS open end-systems to meet the following Physical Layer interface requirements:

(a) Data rate: Line speeds up to 64 kbps are supported.

(b) Cable length: Cable lengths up to 50 feet (maximum) are supported.

(c) Mechanical: A 34-pin connector is defined in ISO 2593.

(d) Electrical: A combination of unbalanced voltage and balanced current is supported. Data and clock circuits are driven by balanced generators. These are not compatible with RS-422A circuits. Control signals are unbalanced and compatible with the RS-232C standard.

(e) Functional: The functional interface circuits are identical to the circuits defined in the RS-232C standard.

3.2.2.4.2.5 V.32. V.32 is a CCITT recommendation for full duplex, low speed transmission over dial-up lines. The V.32 modem provides for leased and dial line communication. It also provides synchronous, asynchronous, and auto dialing modes. This standard shall be used by NAS open end-systems to meet the following Physical Layer interface requirements:

(a) Data rate: Line speeds up to 9.6 kbps are supported.

(b) Mechanical: A terminal interface (25 pin) is supported. The mechanical characteristics of EIA-232D and CCITT V.24/V.28 are supported. A line interface (modular jack or terminal) is supported.

3.2.2.4.2.6 ISO 8802-x and ISO 9314-1. IEEE has approved several interface standards for the Physical Layer for operation in the 1 to 16 Mbps range. ISO has also adopted the IEEE LAN standards for use in OSI compliant networks. NAS open end-systems shall implement ISO 8802-2 and ISO 8802-3 which have been adopted as FIPS PUB 107 for federal LAN implementations when required to use a collision detection access protocol. ISO 8802-3 is similar, but not compatible with Ethernet. NAS open end-systems shall implement ISO 8802-4 when required to use a token passing protocol suitable for broadband bus architectures. It has four levels of priority and can operate at 1, 5, 10, or 16 Mbps. NAS open end-systems shall implement ISO 8802-5 when required to use a token passing protocol suitable for ring architectures. It has eight levels of priority and can operate at 1, 4, or 16 Mbps. NAS open end-systems shall implement ISO 9314-1 fiber optic ring LAN standard operating at 100 Mbps, when required to use a connectionless token passing protocol. This standard is titled Fibre Distributed Data Interface (FDDI).

3.3 Naming and Addressing. Naming and addressing requirements for NAS open systems (i.e., intermediate and end-systems) shall be in accordance with FAA-STD-042. Naming and addressing requirements for Aeronautical Telecommunication Network (ATN) open systems shall be in accordance with the ATN Manual.

3.4 OSI Directory Services. NAS open end-systems that use directories shall implement OSI Directory Services as specified in FAA-STD-044.

3.5 OSI Network Management. Work to establish U.S. Government and international standards on network management is underway; however, general implementation of the international work has not yet been accomplished. As an interim measure, the U.S. Government may adopt an industry standard for network management. Network Management requirements shall conform to ISO 7498-4.

3.6 OSI Security. The OSI security model has recently been approved as an international standard (ISO 7498-2), but no actual mechanisms have been agreed upon to implement the security model. The OSI security work is not sufficiently advanced at this time for this standard to levy NAS-wide security requirements.

3.7 OSI Priority. NAS open end systems that require the transmission of prioritized data shall use the priority indicators as specified in FAA-STD-043. NAS open end systems that communicate with the ATN shall use the priority indicators specified in the ATN Manual.

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4. QUALITY ASSURANCE PROVISION

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5. PREPARATION FOR DELIVERY

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6. NOTES

6.1 Definitions. The terms defined below are frequently used throughout this document. They are defined here to assist in the understanding of the information presented herein.

Protocol - In the Open System Interconnection reference model, the communications functions are partitioned into seven layers. Each layer, N, provides a service to the layer above N+1, by carrying on a conversation with the layer N on another processor. The rules and conventions of that N-layer conversation are called the protocol.

End-system - An end-system contains the application processes that are the ultimate sources and destinations of user-oriented message flows. The functions of an end-system can be distributed among more than one processor/computer.

Intermediate System - A system providing an OSI reference model network layer relay function (that is, a system that receives data from one correspondent Network entity and forwards it to another corresponding Network entity).

Open System - An open system is a system capable of communicating with other open systems by virtue of implementing OSI protocols and services. End-systems and intermediate systems are open systems. However, an open system may not be accessible by all other open systems. This isolation may be provided by physical separation or by technical capabilities based upon computer and communications security.

OSI Environment - Is concerned with the exchange of information between open systems (and not the internal functioning of each individual real open system).

OSI is concerned only with interconnection of systems. All other aspects of systems which are not related to interconnection are outside the scope of OSI.

OSI is concerned not only with the transfer of information between systems, i.e., transmission, but also with their capability to interwork to achieve a common (distributed) task. In other words, OSI is concerned with the interconnection aspects of cooperation between systems.

6.2 Acronyms and Abbreviations. The following are definitions of acronyms and abbreviations used in this standard.

AAS	advanced automation system
ACSE	association control service element
AD	addendum
ANSI	American National Standards Institute
ASE	application service element
ASN	abstract syntax notation
ATN	aeronautical telecommunication network
BA	balanced asynchronous
BER	bit encoding rules
BIS	boundary intermediate system
CCITT	International Telegraph and Telephone Consultative Committee
CLNS	connectionless network service
CONS	connection-oriented network service
CRC	cyclic redundancy check
CSMA/CD	carrier sense multiple access/collision detection
DAD	draft addendum
D-bit	delivery confirmation bit
DCE	data circuit-terminating equipment
DIS	draft international standard
DTE	data terminal equipment
EIA	Electronics Industries Association
ES	end-system
FAA	Federal Aviation Administration
FDDI	fibre distributed data interface
FED	federal
FIPS	federal information processing standards
FTAM	file transfer access and management
GOSIP	Government Open Systems Interconnection Profile
HDLC	high-level data link control
I-frame	information
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IRD	interface requirements document
IS	intermediate system
ISO	International Organization for Standardization
kbps	kilobits per second
kHz	kilohertz
LAN	local area network
LAPB	link access procedure balanced
LCN	local communications network
LLC	logical link control

LL	local loopback
MAC	media access control
Max	maximum
M-bit	more data bit
Mbps	megabits per second
MHS	message handling service
MLP	multilink procedure
NADIN	National Airspace Data Interchange Network
NAS	National Airspace System
NBS	National Bureau of Standards
NIST	National Institute of Standards and Technology
NIU	network interface unit
NRM	normal response mode
NSAP	network service access point
OSI	Open Systems Interconnection
PAD	packet assembler/disassembler
PHY	physical
PUB	publication
PVC	permanent virtual circuit
Q-bit	qualifier bit
RI	ring indicator
RL	remote loopback
RPOA	Registered Private Operating Agency
ROSE	remote operation service element
RS	recommended standard
STD	standard
TM	test mode
TM	trade mark
TP	transaction processing
TPDU	transport protocol data unit
TSAP	transport service access point
V	volts
VC	virtual call
VT	virtual terminal
WAN	wide area network

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APPENDIX I

10. X.25 Services.

NAS open systems shall implement the following X.25 services in accordance with CCITT X.25 (1984 version):

(1) Types of Service -- There are two types of services: virtual call (VC) and permanent virtual circuit (PVC). The former service is the most commonly used. Virtual calls go through three phases: call set-up, data transfer, and call clearing. An X.25 option, "Fast Select," allows small amounts of data to be transmitted during call set-up and allows immediate call clearing. This combines the three phases and minimizes the overhead involved. PVCs are initiated when users join the network and are left connected permanently; therefore, there is no call set-up or call clearing. PVCs are used when data is frequently exchanged and the delay involved in call set-up is not acceptable. Since the end users and the network or networks involved in a PVC must permanently reserve resources for these circuits, they should be used only where a true need exists.

(2) Delivery Confirmation Bit (D-Bit) -- End-to-End delivery confirmation is a layer 4 function in the OSI model. However, it can sometimes be useful to have this function performed in the Network Layer. In the normal mode of operation, the communications equipment acknowledges receipt of a packet back to the sender immediately. Setting the D-bit to "1" causes the communications equipment to withhold this acknowledgment until confirmation of receipt of a packet by the destination DTE has been received by the communication equipment. This can be useful if the particular connection does not use a standard layer 4 protocol providing end-to-end confirmation. An example would be the gateway between NADIN PSN and MSN. Since the use of the D-bit can limit throughput and increase delay time it, should not be used unless it is absolutely necessary. Throughput reduction can be minimized by using the D-bit in coordination with the M-bit.

(3) The More Data Mark (M-bit) -- The M-bit is used to mark a sequence of multiple data packets, typically packets that are part of a single message. Setting the M-bit to "1" indicates that more packets in the same sequence are to be received at the destination DTE. The Network Layer entity in the destination DTE will reassemble the packets into a single message before passing the message up to the Transport Layer. The most efficient way of combining the M-bit and the D-bit is to set the D-bit to "1" on only the last packet of a sequence. X.25 networks deliver packets in order, therefore, if end-to-end acknowledgment of the last packet is received, it guarantees that the entire sequence was received.

(4) Data Qualifier Bit (Q-bit) -- The data qualifier bit, the Q-bit, is sent transparently by X.25 networks. This means that it can be used by the two DTEs for any predefined purpose. Its use in communicating with packet assemblers/disassemblers (PAD) is described by CCITT Recommendation X.29. Because of potential unforeseen problems, it is recommended that this bit not be used except for communicating with PADs.

(5) Nonstandard Default Packet Size -- The standard default packet size for X.25 networks is 128 octets of user data. The NADIN PSN's initial default packet size is 256 octets. This is the maximum amount of user data in a packet. Smaller amounts of data can be sent and no padding is required. This facility would be selected if a different size packet would optimize information transfer. It is more efficient to minimize the number of packets, thus, if a user typically sends lone, multi-packet messages, a larger packet size will improve performance. Excessively large packet sizes, on the other hand, waste buffer space in both the DTE and the network. Values other than the default value can be selected during call set-up using the "flow control parameter negotiation" facility.

(6) Nonstandard Default Window Size -- The window size is the number of packets that can be outstanding for which an acknowledgment has not yet been received by the DTE or DCE. The standard default window size is 2, thus, if there are two outstanding packets, the sending DTE cannot send additional packets until one or both have been acknowledged by the receiving DCE. The window size can be adjusted to optimize performance. Too large a window requires large buffers and may result in many packets being retransmitted if an error occurs. Too small a window results in frequent flow control restrictions and lower throughput. Values other than the default value can be selected during call set-up via the "flow control parameter negotiation" facility.

(7) Closed User Group-Related Facilities -- This is a group of seven related facilities that allow limits to be placed on users relating to which users they may call or which users may call them. Examples include a closed user group with incoming access (members of the group can call only each other, but anyone can call into the group), and outgoing calls barred within a closed user group (members of the group cannot call each other, but may call or be called by anyone else). In the NAS, external users such as airlines will be restricted from calling any addresses other than those to which they have authorized access.

(8) Call Redirection -- If this facility is used, it must be subscribed to; it cannot be selected on a call-by-call basis. It allows calls to be redirected if the destination DTE is out of service or busy. The destination DTE subscribes to the type of call redirection desired. Four options are allowed by the NADIN PSN network: no redirection, automatic redirection, semi-automatic redirection, or manual redirection. Automatic redirection occurs immediately upon detection of the destination being out of service. Semi-automatic redirection occurs after a destination fails and the NADIN PSN Network Control Center (NCC) authorizes redirection. Manual redirection occurs upon command from the network control center. Up to three alternate subnetwork addresses can be associated with a given desired destination address. They form a list that is tried in order if automatic redirection is used. If manual or semi-automatic redirection has been selected, the network control center specifies which of the three alternate addresses is to be used.